NASA/TM-2000-209891, Vol. 39



Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and David E. Knapp, Editors

Volume 39 BOREAS HYD-9 Tipping Bucket Rain Gauge Data

N. Kouwen, R. Soulis, W. Jenkinson, A. Graham, and T. Neff

National Aeronautics and Space Administration

Goddard Space Flight Center Greenbelt, Maryland 20771

The NASA STI Program Office ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

- TECHNICAL PUBLICATION. Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA's counterpart of peer-reviewed formal professional papers but has less stringent limitations on manuscript length and extent of graphic presentations.
- TECHNICAL MEMORANDUM. Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.
- CONTRACTOR REPORT. Scientific and technical findings by NASA-sponsored contractors and grantees.

- CONFERENCE PUBLICATION. Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or cosponsored by NASA.
- SPECIAL PUBLICATION. Scientific, technical, or historical information from NASA programs, projects, and mission, often concerned with subjects having substantial public interest.
- TECHNICAL TRANSLATION.
 English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results . . . even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at http://www.sti.nasa.gov/STI-homepage.html
- E-mail your question via the Internet to help@sti.nasa.gov
- Fax your question to the NASA Access Help Desk at (301) 621-0134
- Telephone the NASA Access Help Desk at (301) 621-0390
- Write to:
 NASA Access Help Desk
 NASA Center for AeroSpace Information
 7121 Standard Drive

Hanover, MD 21076-1320

NASA/TM-2000-209891, Vol. 39



Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and David E. Knapp, Editors

Volume 39 BOREAS HYD-9 Tipping Bucket Rain Gauge Data

Nick Kouwen, Ric Soulis, Wayne Jenkinson, Allyson Graham, and Todd Neff University of Waterloo, Waterloo, Ontario, Canada

National Aeronautics and Space Administration

Goddard Space Flight Center Greenbelt, Maryland 20771

	Available from:	
NIACA Contourfour Armongue II C		Notional Tasks: -1 Informed C
NASA Center for AeroSpace Information		National Technical Information Service
7121 Standard Drive		5285 Port Royal Road
Hanover, MD 21076-1320		Springfield, VA 22161
Drica Codo: A17		Dring Code, A10
Price Code: A17		Price Code: A10

BOREAS HYD-9 Tipping Bucket Rain Gauge Data

Nicholas Kouwen, Ric Soulis, Wayne Jenkinson, Allyson Graham, Todd Neff

Summary

The BOREAS HYD-9 team collected several data sets containing precipitation and streamflow measurements over the BOREAS study areas. This data set contains the measurements from the tipping bucket rain gauges at the BOREAS NSA and SSA. These measurements were submitted in 15-minute and 1-hour intervals. Only the 15-minute interval data set was loaded into the data base tables. Data were collected from the tipping bucket gauges from mid-April until mid-October in 1994, 1995, and 1996. The data are available in tabular ASCII files.

Table of Contents

- 1) Data Set Overview
- 2) Investigator(s)
- 3) Theory of Measurements
- 4) Equipment
- 5) Data Acquisition Methods
- 6) Observations
- 7) Data Description
- 8) Data Organization
- 9) Data Manipulations
- 10) Errors
- 11) Notes
- 12) Application of the Data Set
- 13) Future Modifications and Plans
- 14) Software
- 15) Data Access
- 16) Output Products and Availability
- 17) References
- 18) Glossary of Terms
- 19) List of Acronyms
- 20) Document Information

1. Data Set Overview

1.1 Data Set Identification

BOREAS HYD-09 Tipping Bucket Rain Gauge Data

1.2 Data Set Introduction

This data set contains the measurements from the tipping bucket rain gauges at the BOReal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) and Southern Study Area (SSA). These measurements were submitted in 15-minute and 1-hour intervals. Only the 15-minute interval data set was loaded into the data base tables. Data were collected from the Belfort gauges from mid-April until mid-October in 1994, 1995, and 1996.

1.3 Objective/Purpose

This project will seek to identify, through field measurements and computer modeling, the space-time distribution of meltwater supply to the soil during the spring melt period and the evolution of soil moisture, evaporation, and runoff from the end of the snowmelt period through freeze up. The

snow modeling activity will consist of two components. The first will use existing "off-the-shelf" models to forecast the onset and spatial extent of snowmelt and meltwater supply to the soil column prior to the 1994 Intensive Field Campaigns (IFCs). The second phase will extend, implement, and verify a physically based energy balance snowmelt model of the two sites and will evaluate approaches to aggregating detailed snowmelt predictions and measurements based on the model to larger scales, up to the size of a rectangle of several hundred km containing the northern and southern sites. The soil moisture modeling is based on a grouped response unit method that will allow characterization of soil moisture, evaporation, and runoff for the entire northern and southern sites.

1.4 Summary of Parameters

The following phenomena and their parameters are being reported: precipitation amount in a 15-minute period.

1.5 Discussion

The locations for 12 tipping bucket measuring devices, 10 Belfort gauges, and 5 stream sites were selected within the two BOREAS study sites (NSA and SSA). These instruments were installed during the 1994 Focused Field Campaign-Thaw (FFC-T) in the last week of April. They were in operation until October 1994, when they were removed from service. The tipping buckets and Belfort gauges provided an approximate measure of the precipitation in the study areas, and the discharge rates of the streams provided a measurement of water leaving the study area. When used together, these two sets of data provide a balance of the water cycle. Similar measurements were collected in 1995 and 1996 from approximately April to October of those years.

1.6 Related Data Sets

BOREAS HYD-09 Belfort Rain Gauge Data BOREAS HYD-09 Stream Flow Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

Prof. Ric Soulis University of Waterloo Department of Civil Engineering

2.2 Title of Investigation

From Micro-Scale to Meso-Scale Snowmelt, Soil Moisture and Evapotranspiration from Distributed Hydrologic Models

2.3 Contact Information

Contact 1:

Dr. Nicholas Kouwen Univ. of Waterloo Dept. of Civil Engineering Waterloo, ON N2L 3G1 CANADA (519) 885-1211 x3309 (519) 888-6197 (fax) kouwen@sunburn.uwaterloo.ca

Contact 2:

Dr. Ric Soulis Univ. of Waterloo Dept. Civil Engineering Waterloo, ON N2L 3G1 CANADA (519) 885-1211 x2175 (519) 888-6197 (fax) ric@sunburn.uwaterloo.ca

Contact 3:

David Knapp Raytheon ITSS NASA GSFC Code 923 Greenbelt, MD 20771 (301) 286-1424 David.Knapp@gsfc.nasa.gov

3. Theory of Measurements

A tipping bucket gauge consists of a conical funnel attached to the top of a cylinder for support. It is designed to find the vertical depth of water that would accumulate on a level surface if the precipitation remained where it fell. A small container separated into two parts is located underneath the funnel. One of these parts, a bucket, is angled beneath the funnel where it can collect water. When one of the buckets is filled with a specific amount of rain (usually 0.1 or 0.2 mm), it tips down and releases the water into a reservoir. This tipping action brings the other bucket up into place beneath the funnel much as a teeter totter would. The container must be balanced correctly in order to achieve this motion. When the bucket tips down, it activates a switch that prompts a data logger to record the information. Because it is already known exactly how much water causes the bucket to drop (through calibration), a graph of precipitation versus time can be created.

4. Equipment

4.1 Sensor/Instrument Description

Tipping Bucket:

A tipping bucket gauge is a device used to measure the amount of precipitation in a given area. When a specific amount of rainfall fills one of the buckets, the bucket tips and triggers a switch. The accumulated number of bucket tips is recorded at regular intervals by an electronic data logger. One of the tipping bucket gauges (TB-SW2) had a 9.664-inch diameter opening, and the buckets were tipped after 0.1 mm of rainfall. The other tipping bucket gauges had 12-inch diameter openings, and the buckets were tipped after 0.2 mm of rainfall.

Data Logger:

The chart pac CP-X data logger was connected to the tipping bucket rain gauge and programmed to record the cumulative number of tips that occurred in a 15-minute period. The data logger stored the information in its memory until it was retrieved.

4.1.1 Collection Environment

The equipment was operated in variable ambient atmospheric conditions at the field sites in Saskatchewan and Manitoba during 1994.

4.1.2 Source/Platform

Tipping buckets were mounted on a wide wooden base placed on the ground. The data loggers were mounted inside watertight containers placed adjacent to the tipping buckets.

4.1.3 Source/Platform Mission Objectives

In order to make sufficient precipitation data, a detailed estimate of the total amount of precipitation must be collected to account for all peak periods of precipitation and any variations that occur with time. To achieve this, the data were recorded at regular intervals of 15 minutes. The data logger stored the information until it was retrieved. Tipping bucket and Belfort gauges were used to provide independent measures of precipitation in order to reduce errors.

4.1.4 Key Variables

- Tipping Buckets Precipitation amount in a 15-minute period
- Data Logger Voltage

4.1.5 Principles of Operation

The tipping bucket is a self-contained device designed to measure the amount of precipitation occurring in a given area over time. It is only an estimate of the total rainfall in an area. The amount of water is measured by the triggering of a weight-activated switch whenever a certain volume of water has fallen.

4.1.6 Sensor/Instrument Measurement Geometry

The tipping bucket gauge is mounted at ground level. It must be in a clearing large enough so that a 45-degree inverted cone originating from its highest point can reach the atmosphere unimpeded. If trees or other obstructions are surrounding the tipping bucket, they will affect the data. The device should be mounted on a stable base (example: a wooden platform) and leveled so that the cone is completely vertical (i.e., axis of gauge is perpendicular to a water level).

4.1.7 Manufacturer of Sensor/Instrument

Tipping Bucket Gauges - Environmental Measurements Ltd. ARG 100 Rain Gauge 3 Stepcentre Osney Mead, Oxford, England OX2 0ES 011-44-0865-724-240

Texas Electronics, Inc. 5529 Redfield St. P.O. Box 7225 Inwood Station Dallas, TX 75209 (214) 631-2490

Data Logger - Lakewood Systems Edmonton, Alberta, Canada (403) 462-9211

4.2 Calibration

A tipping bucket is calibrated by slowly pouring a known amount of water into the funnel and counting how many bucket tips occur. This will allow for the calculation of the exact volume of water per bucket tip, which can be compared to the device's specifications. For example, if the company says that the bucket will tip when the bucket is filled with 4.73 ml of water and this amount is equivalent to 0.1 mm of rainfall, but the calibration shows that the device actually holds 5.00 ml per bucket tip, then this amount is equivalent to 0.106 mm of rainfall ([5.0/4.73] * 0.1 mm = 0.106 mm of

precipitation).

4.2.1 Specifications

Tipping Bucket - orifice opening: 12-inch diameter opening on 11 of the gauges; TB-SW2 (called SSA-TB7-HYD09-TBRG07 in the data base) has a 9.664-inch diameter opening.

Frequency of tipping action: every 0.2 mm of rainfall for 11 of the gauges; TB-SW2 (called SSA-TB7-HYD09-TBRG07 in the data base) tips after 0.1 mm of rainfall.

4.2.1.1 Tolerance

A tipping bucket can measure an infinite amount of water (if data storage is unlimited) in increments of 0.2 mm or 0.1 mm of rainfall. The recorded rainfall is within 1.0% of the actual rainfall amount when the amount of rainfall is 2 inches per hour or less. When the rainfall rate exceeds 2 inches per hour, water may spill over the edges of the bucket and not be counted.

4.2.2 Frequency of Calibration

The tipping buckets were calibrated once at the beginning, the middle, and the end of the study period.

4.2.3 Other Calibration Information

None.

5. Data Acquisition Methods

A data logger recorded the precipitation data for the tipping bucket gauges. The data logger was connected to a notebook computer onsite, where the logger's stored information was transferred to the notebook. The number of tips was then converted to precipitation and checked for quality.

6. Observations

6.1 Data Notes

<u>Instrument</u>	Year	<u>Date</u>	Event
Tipping Bucket 1,	1994	10-APR	TB1 installed
Tipping Bucket 10		16-OCT	TB1 removed
Note: TB 1 was	1995	11-APR	TB1 installed
moved May 31, 1995,		18-APR - 26-APR	Missing data - mechanical problems
and renamed TB 10		06-MAY- 31-MAY	Missing data - mechanical problems
		31-MAY	TB1 removed
		01-JUN	TB10 installed at new location
		01-JUN - 06-JUL	Missing data - mechanical problems
		07-NOV	TB10 removed
	1996	15-APR	TB10 installed
		15-APR - 26-JUL	Missing data
		26-JUL	Battery flat - logger recharged and started with
			226 tips
		06-NOV	TB10 removed

Instrument Tipping Bucket 2	<u>Year</u> 1994	Date 11-APR	Event TB2 installed
	1995	17-OCT 11-APR	TB2 removed TB2 installed
	1006	07-NOV	TB2 removed
	1996	01-APR 25-JUL - 19-AUG	TB2 installed
		06-NOV	TB2 removed
Tipping Bucket 3	1994	11-APR	TB3 installed
		25-MAY	Missing data
	1995	18-OCT	TB3 removed TB3 installed
	1993	11-APR 07-NOV	TB3 removed
	1996	16-APR	TB3 installed
	1770	27-MAY- 05-JUN	
		06-NOV	TB3 removed
Tipping Bucket 4	1994	12-APR	TB4 installed
FF 8		17-OCT	TB4 removed
	1995	26-APR	TB4 installed
		15-JUL -08-NOV	Missing data
		08-NOV	TB4 removed
	1996	01-APR	TB4 installed
		06-NOV	TB4 removed
Tipping Bucket 5	1994	20-APR	TB5 installed
PP8 2 4 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		17-OCT	TB5 removed
	1995	-	Not installed
	1996	-	Not installed
Tipping Bucket 6,	1994	04-MAY	TB6 installed
Tipping Bucket 6A	1,,,	17-OCT	TB6 removed
Note: TB6 was	1995	12-APR	TB6 installed
moved July 15, 1996,		08-NOV	TB6 removed
and renamed TB6A	1996	16-APR	TB6 installed
		15-JUL	Moved to Old Black Spruce (OBS) Tower,
			renamed TB6A
		06-NOV	TB6A removed
Tipping Bucket 7	1994	04-MAY	TB7 installed
		16-OCT	TB7 removed
	1995	11-APR	TB7 installed
		09-MAY - 12-MAY	C
	1006	07-NOV	TB7 removed
	1996	16-APR	TB7 installed
		06-NOV	TB7 removed
Tipping Bucket 8	1994	-	Not installed
rr 8	1995	12-MAY	TB8 installed
		08-NOV	TB8 removed
	1996	27-JUL	TB8 installed
		12-OCT	TB8 removed

Instrument Tipping Bucket 9, Belfort 4 Note: Was installed as Bel4 in 1994, TB9 in 1995 and 1996	Year 1994 1995 1996	Date - 12-MAY 08-NOV 23-AUG 06-NOV	Event Installed as Bel4 - see Belfort information TB9 installed TB9 removed TB9 installed TB9 removed
Tipping Bucket 21, Belfort 24 Note: TB21 was installed as Bel24 in 1995 and 1996	1994 1995 1996	27-APR 27-APR - 18-MAY 14-OCT -	TB21 installed Missing data TB21 removed Installed as Bel24 - see Belfort information Installed as Bel24 - see Belfort information
Tipping Bucket 22	1994 1995 1996	26-APR 18-MAY 12-JUL 22-JUL - 23-JUL 14-OCT 29-APR 10-NOV	TB22 installed Missing data Spider's nest found in tipping bucket. Water stored in nest released and recorded as precipitation. Evaporation losses likely. Missing data TB22 removed TB22 installed TB22 removed No reasonable data
Tipping Bucket 23	1994 1995 1996	27-APR 14-OCT 29-APR 10-NOV 15-APR * 06-NOV	TB23 installed TB23 removed TB23 installed TB23 removed TB23 installed partial record TB23 removed
Tipping Bucket 24, Belfort 25 Note: TB24 was installed as Bel25 in 1995 and 1996	1994 1995 1996	27-APR 14-OCT -	TB24 installed TB24 removed Installed as Bel25 - see Belfort information Installed as Bel25 - see Belfort information
Tipping Bucket 25	1994 1995 1996	28-APR 14-OCT 16-MAY 16-NOV 13-APR 24-OCT	TB25 installed TB25 removed TB25 installed - daily values until 06/18 TB25 removed TB25 installed TB25 removed
Tipping Bucket 26, Belfort 21 Note: Was installed as Bel21 in 1994, TB26 in 1995 and 1996	1994 1995 1996	- 29-APR 24-AUG 10-NOV	Installed as Bel21 - see Belfort information TB26 installed Gauge leveled, logger restarted TB26 removed No reasonable data

Instrument Tipping Bucket 27, Belfort 23 Note: Was installed as Bel23 in 1994, TB27 in 1995 and 1996	Year 1994 1995 1996	Date - 29-APR 04-JUL - 01-AUG 10-NOV 14-APR 10-JUN 25-OCT	Event Installed as Bel23 - see Belfort information TB27 installed Missing data TB27 removed TB27 installed Gauge found knocked over and damaged - replaced and reset TB27 removed
Tipping Bucket 28, Belfort 22 Note: Was installed as Bel22 in 1994, TB28 in 1995 and 1996	1994 1995 1996	- - -	Installed as Bel22 - see Belfort information No reasonable data No reasonable data
Tipping Bucket 29 Note: Was installed very near TB28 as a backup gauge	1996	02-JUN 25-OCT	TB29 installed TB29 removed

6.2 Field Notes

None given.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

Twelve tipping buckets were set within and around the boundaries of the water basins to give an estimate of the precipitation within these boundaries. Each tipping bucket gauge was a point measurement of the precipitation, making the total area of coverage very small. From these point measurements, the average precipitation for the study basins could be estimated. Together, they represent the total rainfall in the area. The size of both northern water basins being studied is 27 km², while the size of the southern water basin is 574 km². The following table lists the tipping bucket rain gauges used and their locations. These coordinates are in the North American Datum of 1983 (NAD83).

SITE_ID	LONGITUDE	LATITUDE
NSA-T21-HYD09-TBRG21	98.34275W	55.91236N
NSA-T22-HYD09-TBRG22	98.43671W	55.88842N
NSA-T23-HYD09-TBRG23	98.37767W	55.88866N
NSA-T24-HYD09-TBRG24	98.56599W	55.92662N
NSA-T25-HYD09-TBRG25	98.44883W	55.91119N
NSA-T26-HYD09-TBRG26	98.4111W	55.88856N
NSA-T27-HYD09-TBRG27	98.55822W	55.89147N
NSA-T28-HYD09-TBRG28	98.49892W	55.77653N
NSA-T29-HYD09-TBRG28	98.49892W	55.77653N
SSA-TB1-HYD09-TBRG01	105.13441W	53.93336N
SSA-TB2-HYD09-TBRG02	104.73677W	53.98388N

```
SSA-TB3-HYD09-TBRG03 104.70427W 54.04309N

SSA-TB4-HYD09-TBRG04 104.87348W 54.15781N

SSA-TB5-HYD09-TBRG05 104.93682W 54.05218N

SSA-TB6-HYD09-TBRG06 105.11288W 53.99847N

SSA-T6A-HYD09-TBRG6A 105.1170W 53.99872N (approximated)

SSA-TB7-HYD09-TBRG07 104.68167W 53.895N

SSA-TB8-HYD09-TBRG08 104.89617W 54.00469N

SSA-TB9-HYD09-TBRG09 104.93681W 54.05247N

SSA-T10-HYD09-TBRG10 105.14389W 53.91883N
```

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

Because the data were gathered as point measurements, the resolution of the resultant data is very low. They are meant only to give the average precipitation rates at 15-minute intervals for the study basins.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

Data were collected from the tipping bucket gauges from mid-April until mid-October in 1994, 1995, and 1996.

7.2.2 Temporal Coverage Map

Not available.

REVISION_DATE

7.2.3 Temporal Resolution

Measurements were recorded by the tipping bucket gauges at 15-minute intervals.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what is means will vary with site types.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
TIME_OBS	The Greenwich Mean Time (GMT) when the data were collected.
PRECIPITATION	The amount of precipitation measured by the rain gauge for the 15 minute period preceding the given time.
PARM_VALUE_FLAGS	This contains values or codes that indicate special conditions for the data parameters. See data set documentation for descriptions of these codes.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
PRECIPITATION	[millimeters]
PARM_VALUE_FLAGS	[none]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
DATE_OBS	[Supplied by Investigator]
TIME_OBS	[Supplied by Investigator]
PRECIPITATION	[Supplied by Investigator]
PARM_VALUE_FLAGS	[Supplied by Investigator]
CRTFCN_CODE	[Assigned by BORIS]
REVISION_DATE	[Assigned by BORIS]

7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

Missng Unrel Below Data

	Minimum	Maximum	Missng	Unrel	Below	Data
	Data	Data	Data	Data	Detect	Not
Column Name	Value	Value	Value	Value	Limit	Cllctd
SITE_NAME		SSA-999-TRG06	None	None	None	None
SUB_SITE		HYD09-TRG25	None	None	None	None
DATE_OBS		07-NOV-96	None	None	None	None
TIME_OBS	0	2345	None	None	None	None
PRECIPITATION	0	32.9	-999	None	None	None
PARM_VALUE_FLAGS		•	None	None	None	Blank
CRTFCN_CODE		CPI	None		None	None
REVISION_DATE	19-MAR-96	14-JUL-97	None	None	None	None
Missng Data Value Unrel Data Value	to indicate an attempt was made to determine the parameter value, but the value was deemed to be unreliable by the analysis personnel. mit The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection limit of the instrumentation.			used ned		

```
Blank -- Indicates that blank spaces are used to denote that type of value. N/A -- Indicates that the value is not applicable to the respective column. None -- Indicates that no values of that sort were found in the column.
```

7.4 Sample Data Record

The following are wrapped versions of data records from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,PRECIPITATION,PARM_VALUE_FLAGS,CRTFCN_CODE,REVISION_DATE
'SSA-999-TRG05','HYD09-TRG05',01-JUN-94,0,0.0,'','CPI',19-MAR-96
'SSA-999-TRG05','HYD09-TRG05',01-JUN-94,15,0.0,'','CPI',19-MAR-96
```

8. Data Organization

8.1 Data Granularity

The smallest amount of data that can be ordered from this data set is a day's worth of data for a given site.

8.2 Data Format(s)

The Compact Disk-Read Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

After a tipping bucket has been calibrated, the amount of precipitation per measuring period can be found by using:

Total precipitation = # of tips * precipitation per tip i.e., 4.5 mm = 45 tips * 0.1 mm per tip

9.1.1 Derivation Techniques and Algorithms

At regular intervals during the monitoring period, the accumulated number of bucket tips that had occurred was recorded on a data logger. The bucket tips were then converted to precipitation using the calibration coefficient. If the tipping bucket was reset (data logger started to record from zero again), then the data were adjusted accordingly.

9.2 Data Processing Sequence

9.2.1 Processing Steps

The following steps were performed to collect the data:

- Set up necessary equipment.
- Record the number of bucket tips over time.
- Calculate the precipitation rates using a coefficient.
- Enter the precipitation rates into ASCII files with the appropriate identifying information noted beside each row (location, year, day, month).
- Add the necessary column headings.
- Transfer the information to the data base.

BORIS processed the data by:

- Reviewing the initial data files and loading them online for BOREAS team access.
- Designing relational data base tables to inventory and store the data.
- Loading the data into the relational data base tables.
- Working with the Hydrology (HYD)-09 team to document the data set. 5) Extracting the standardized data into logical files.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None.

9.3.2 Calculated Variables

None.

9.4 Graphs and Plots

See associated report file "hyd09 report.pdf" (an Adobe Acobat file).

10. Errors

10.1 Sources of Error

Most of the errors occur during the actual measuring of the precipitation. Some of the smaller sources of error occur from water splashing out of the funnel, water evaporating from the reservoir that cannot be measured, water used to initially wet the gauge's surface, and gauges that are not perfectly level.

A larger source of error is the wind, which can cause turbulent air flow around the gauge, creating updrafts and downdrafts that interfere with the normal path of precipitation. A high wind speed will also create compressed lines of flow, reducing the amount of precipitation that enters the gauge. The higher the wind speed, the greater the effect on the measured precipitation.

During high levels of precipitation, water is not measured precisely because of its high rate of flow. Extra water, in addition to what is required to tip the bucket, pours into the bucket while it is in the process of tipping. This extra water is not accounted for and is lost. If the collecting rim (funnel opening to the outside) is damaged in any way, the amount of precipitation being measured will be changed because less water enters the gauge than what it was calibrated for.

10.2 Quality Assessment

10.2.1 Data Validation by Source

The effects of the wind were reduced considerably by placing the gauges in clearings surrounded by forest, which shielded the gauge from oncoming winds. To try to account for high precipitation rates, water was collected in an independent, manually read gauge and compared to what the data logger had recorded over the same time period. If the two methods were significantly different, corrections were made. After the information had been collected, it was run through an algorithm to detect any data that were abnormal when compared to the rest of the data. Computer programs were also used to adjust the gauges for periods when they had missing lids.

There may be anomalies in the data that could not be resolved at the time these data were published. Please consult the data notes (Section 6.1) for information that might give some indication about the source of any anomalies.

10.2.2 Confidence Level/Accuracy Judgment

The confidence level of the data varies with the particular tipping bucket gauge at the time of measurement.

10.2.3 Measurement Error for Parameters

The collected data will eventually be compared to radar data and the calibration measurements, but at this time no steps have been taken to carry this out.

10.2.4 Additional Quality Assessments

None.

10.2.5 Data Verification by Data Center

Data that were loaded into the data tables were spot checked against the original ASCII data that were submitted to check for data loading errors.

11. Notes

11.1 Limitations of the Data

None given.

11.2 Known Problems with the Data

See Section 6.1.

11.3 Usage Guidance

Because of the problems that occurred, some periods of precipitation are not accurate.

11.4 Other Relevant Information

HYD-09 wrote a report stored on this CD-ROM called "hyd09_report.pdf" (an Adobe Acobat file). It can be referenced as:

Kouwen, N., R. Soulis, W. Jenkinson, A. Graham, and T. Neff. 1997. BOREAS: Boreal Forest Hydrological Research Study. Hydrology 9 Group: From Micro-scale to meso-scale snowmelt, soil moisture and evapotranspiration from distributed hydrological models, University of Waterloo, Dept. of Civil Engineering, August 1997.

12. Application of the Data Set

These data can be used for precipitation distribution, soil moisture, and other hydrological studies.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description

Several computer programs are required to convert the data logger information into precipitation and to check it for quality.

14.2 Software Access

None given.

15. Data Access

The HYD-09 tipping bucket rain gauge data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407

Phone: (423) 241-3952 Fax: (423) 574-4665

E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/.

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

None.

16.2 Film Products

None.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

Environment Canada: Atmospheric Environment Service. Tipping Bucket Rain Gauge System. 1981.

Hoskin Scientific Limited. 1992. Chart pac Cp-X (price and specification sheet).

Kouwen, N., R. Soulis, W. Jenkinson, A. Graham, and T. Neff. 1997. BOREAS: Boreal Forest Hydrological Research Study. Hydrology 9 Group: From Micro-scale to meso-scale snowmelt, soil moisture and evapotranspiration from distributed hydrological models, University of Waterloo, Dept. of Civil Engineering, August 1997.

Texas Electronics, Inc. (see 5.1.6). Remote Reading Electric Rain Gauge (specification sheets).

17.2 Journal Articles and Study Reports

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102 (D24): 28,731-28,770.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

AES - Atmospheric Environment Service of Canada

ASCII - American Standard Code for Information Interchange

Bel - Belfort Gauge

BOREAS - BOReal Ecosystem-Atmosphere Study

BORIS - BOREAS Information System

CD-ROM - Compact Disk (optical), Read-Only Memory

DAAC - Distributed Active Archive Center

- Earth Observing System EOS

EOSDIS - EOS Data and Information System FFC-T - Focused Field Campaign - Thaw GIS - Geographic Information System
GMT - Greenwich Mean Time

GSFC - Goddard Space Flight Center

HYD - Hydrology

IFC - Intensive Field Campaign NAD83 - North American Datum of 1983

NASA - National Aeronautics and Space Administration

NSA - Northern Study Area
OBS - Old Black Spruce

ORNL - Oak Ridge National Laboratory PANP - Prince Albert National Park

SSA - Southern Study Area

TB

- Tipping Bucket - Uniform Resource Locator URL

20. Document Information

20.1 Document Revision Dates

Written: 02-Dec-1996 Last Updated: 05-Feb-1999

20.2 Document Review Dates

BORIS Review: 19-Sep-1997 Science Review: 01-Oct-1997

20.3 Document ID

20.4 Citation

When using these data, please include the following acknowledgement as well as citations of relevent papers in Section 17.2:

The efforts of Ric Soulis and Nick Kouwen from the University of Waterloo in collecting these data and making them available as well as the efforts of BORIS staff in processing the data are greatly appreciated.

If using data from the BOREAS CD-ROM series, also reference the data as:

Kouwen, N., R. Soulis, and D. Knapp, "From Micro-Scale to Meso-Scale Snowmelt, Soil Moisture and Evapotranspiration from Distributed Hydrologic Models." in Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A.Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

Also, cite the BOREAS CD-ROM set as:

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. Collected Data of The Boreal Ecosystem-Atmosphere Study. CD- ROM. NASA, 2000.

20.5 Document Curator

20.6 Document URL

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE July 2000	3. REPORT TYPE AND DATES COVERED Technical Memorandum	
4. TITLE AND SUBTITLE Technical Report Series on the Bo BOREAS HYD-9 Tipping Bu	5. FUNDING NUMBERS 923		
6. AUTHOR(S) Nick Kouwen, Ric Soulis, Wayr Forrest G. Hall and David E. Kr		am, and Todd Neff	RTOP: 923-462-33-01
7. PERFORMING ORGANIZATION NAME Goddard Space Flight Center Greenbelt, Maryland 20771	E(S) AND ADDRESS (ES)		8. PEFORMING ORGANIZATION REPORT NUMBER 2000-03136-0
9. SPONSORING / MONITORING AGE National Aeronautics and Space Washington, DC 20546-0001		(ES)	10. SPONSORING / MONITORING AGENCY REPORT NUMBER TM—2000–209891 Vol. 39
11. SUPPLEMENTARY NOTES N. Kouwen, R. Soulis, W. Jen D.E. Knapp: Raytheon ITSS	kinson, A. Graham, T. N	eff: University of	Waterloo;
12a. DISTRIBUTION / AVAILABILITY STA Unclassified—Unlimited Subject Category: 43 Report available from the NASA 7121 Standard Drive, Hanover,	A Center for AeroSpace Info	·	12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The BOREAS HYD-9 team collected several data sets containing precipitation and streamflow measurements over the BOREAS study areas. This data set contains the measurements from the tipping bucket rain gauges at the BOREAS NSA and SSA. These measurements were submitted in 15-minute and 1-hour intervals. Only the 15-minute interval data set was loaded into the data base tables. Data were collected from the tipping bucket gauges from mid-April until mid-October in 1994, 1995, and 1996. The data are available in tabular ASCII files.

14. SUBJECT TERMS BOREAS, hydrology.			15. NUMBER OF PAGES 18
17. SECURITY CLASSIFICATION	18. SECURITY CLASSIFICATION	19. SECURITY CLASSIFICATION	16. PRICE CODE 20. LIMITATION OF ABSTRACT
of REPORT Unclassified	OF THIS PAGE Unclassified	OF ABSTRACT Unclassified	UL UL